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ABSTRACT

An adaptation technique of multimodal interfaces based on a cognitive modeling of users is presented in this paper. The adaptation process tries to select a combination of modalities that best fits the cognitive profile of each user. This profile contains indicators of cognitive abilities and styles. This paper focuses on output modalities and applies the adaptation technique on hypermedia documents. The system presented is implemented using the XML and ASP technologies. The paper describes the supervised cognitive training program called HAPPYneuron[TM], examines the cognitive styles, describes the two main components of the output profile, and illustrates the adaptation process and the document structure. (Author/AEF)

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Cognitive user profile and its involvement into adaptive interface

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ABSTRACT

An adaptation technique of multimodal interfaces based on a cognitive modeling of users is presented this paper. The adaptation process tries to select a combination of modalities that best fit the cognitive profile of each user. This profile contains indicators of cognitive abilities and styles. Today, we focus our attention on output modalities and apply our technique on hypermedia documents. The system we here present is implemented using the XML and ASP technologies.

KEYWORDS: adaptive interface, user modeling, XML document.

INTRODUCTION

Researches on adaptive interfaces and user modeling have attracted attention over a decade ago and seems to have recently aroused a renewal of interest, mainly thanks to hypermedia. As the amount of on-line information grows at an astonishing speed, people feel overwhelmed by the information currently available, and the corresponding media landscape [Elting, 2002]. This clearly leads to a need of automated methods, commonly referred to as adaptive interfaces, that present information with respect to the user's profile. As adaptive interfaces aim at automatically adapting to individual users, the development of appropriate user modeling techniques is of great importance. Techniques dealing with user profile construction are drawn from work from cognitive psychology and human computer interface.

We first describe the supervised cognitive training program called HAPPYneuron™. This program enables the construction of the cognitive profile of users. We then investigate adaptive techniques using this profile. We focus our first work on output modalities in the context of hypermedia. We have chosen XML and ASP technologies to implement the system. Evaluation tests are in progress.

'HAPPYNEURON' SITE DESCRIPTION

In collaboration with the SBT society, we have worked on an interactive web site proposing a supervised cognitive training: www.happyneuron.com [Tarpin-Bernard, 2001]. Mainly dedicated to seniors, this web site provides exercises that train and evaluate cognitive abilities. During each training session (i.e. each connection), the user performs a set of exercises suggested by the system. Presented in a playful and cultural dimension, exercises vary in difficulty level, speed… in order to entertain the user [Habieb-Mammar, 2001].

Normalized data is stored into a database (means and standard deviations) for each variant of exercise and family of population distinguishing gender, educational level and age [Tarpin-Bernard, 2001]. Current statistics show that since the web site was open to the public (summer 2001), the number of performed exercises exceeds 600.000 and the population of players is well distributed between 15 and 80 years of age. Comparing the trainee's results and normalized data, we are able to progressively build the user cognitive profile. It then enables the system to advise the user in his choice of exercises.

In this context, we have built an evaluation module composed of ten precise exercises that enables to quickly build a cognitive profile. Then, this profile, which is quite stable, can be used in very different contexts. Our first purpose is to elaborate an adaptive multimedia course on the brain. Depending on one's profile, the lesson will be presented using the most adapted media.

Before describing the adaptation process module, we may start with the definition of these cognitive styles.

WHAT ARE COGNITIVE STYLES ?

Cognitive styles refer to a person's usual, prevalent, or preferred mode of perceiving, memorizing, learning, judging, decision-making, problem-solving [Dufresne, 1997].

Individual differences about how people carry out tasks involving these functions may constitute a style if they appear to be: pervasive, which means that they consistently emerge in different contexts, independently of the particular features of situation; or stable, that is, they are always the same at different times.

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They are one of the most stable user characteristics overtime. They are consistent across a variety of situations, as opposed to user knowledge or experience that is more specific and evolving. Numerous studies have shown the importance of cognitive styles in the area of HCI research and their implication in the design of the interface [Muylwijk,1983].

Cognitive styles induce people to adopt similar attitudes and behaviors in a variety of domains concerned [Daniels, 1996]. Cognitive styles are important in determining the most effective interface for a particular category of user, especially in the formative stages of an interaction [Fowler, 1985].

They can be conceptualized as a cross-road of thinking, personality, and motivation. In fact they concern the kind of strategies an individual tends to apply when faced to a situation or to the preferred way of processing information.

OUR APPROACH

The two important steps adopted in our approach are structured as follows (figure 1) :

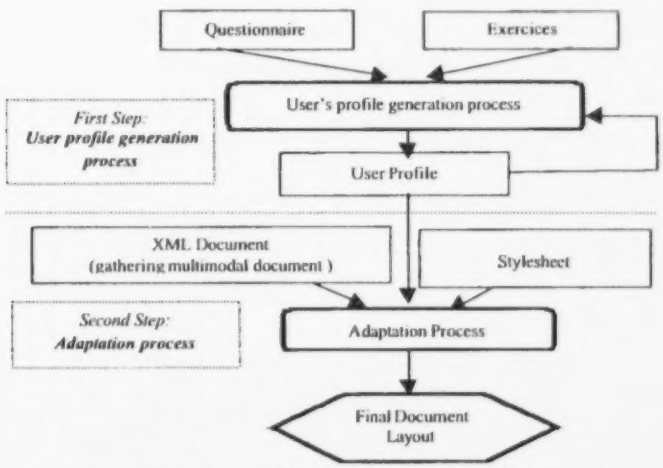

Figure 1: User profile generation and adaptation process

The user's profile generation process consists in executing a sequence of interactive exercises then computing the cognitive profile.

The main components of the output profile are:

1- Cognitive indicators dispatched into 5 sectors: *memory, attention, executive functions, language and visual & spatial capacities* [Tarpin-Bernard, 2001]. In detail, 25 indicators have been determined. We can mention several of them as an illustration: cultural memory, recent memory (verbal, visual or musical), working memory, lexical spelling, categorization, comprehension, planning, reasoning, form recognition, etc ;

2- Styles indicators revealing some cognitive styles such as field dependence. These indicators are determined combinating cognitive indicators or through the comparison of the results obtained in several exercises. For example to determine whether the subject is field dependent or not, we use an indicator which measures the difference in performance after running the same exercise with two different images (the first with significant context and the second with non-significant context) then we adjust it with other cognitive indicators such as recent memory (verbal, visual or musical) and comprehension.

Using the cognitive indicators, we have modeled the cognitive sectors that are most solicited while performing an exercise. However, in practice, an exercise cannot imply a unique sector. Every cognitive activity results from a parallel or hierarchical processing of a lot of cognitive abilities. For each exercise, we have determined the different solicited indicators and chosen weight factors ($0 \leq p_i \leq 10$). After each exercise running, the performance (P) of the user is computed using the average performance (M) and the standard deviation (σ) of this performance that are stored in our database and result from other users which have the same characteristics (age, gender and level of education). A user with an average performance will obtain a score of 50 (the default value)

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and someone with a very good performance of M+2σ will obtain 90 (2,5 % of the population) [Habieb-Mammar, 2001][Tarpin-Bernard, 2001].

This user profile enables the selection of outcome modalities. The multimodal document is defined into an XML document. We here consider the three main modalities: text, image (picture, diagram, video) and sound (music, jingle or voice). Prior to any process, the stylesheet contains the layout of the complete page to be presented. For a specific subject, the final layout of this page is brought through the adaptation process which is mainly a filtering process. According to us, this layout is the most compatible with the user cognitive profile.

To illustrate the adaptation process, we hereafter give an example of a page dealing with the *Memory* item. This page presents two sub-items : "definition of memory" and "mechanism of memory". In the XML document, the page falls under 2 elements. Each one may be presented according to different modalities. *TR* and *TC* stand for Reduced and Complete Textual elements of a page. *IR* and *IC* refer to Image modalities (Reduced and Complete) and *RV* corresponds to a Recorded Voice that explains a concept (figure 2).

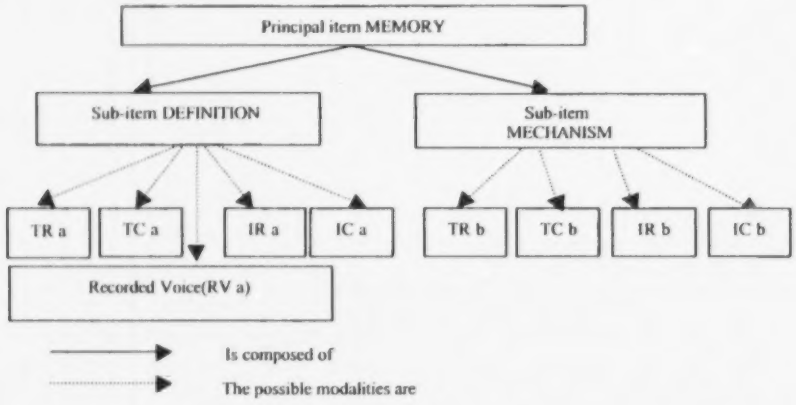

Figure 2: XML document structure

The issue is to find the "best" combination of modalities according to the will of the designer and the abilities of the reader. According to the XML structure, the possible combinations are: (*TRa*, *TCb*), (*TCa*, *IRb*), (*TRa*, *RVa*, *TCb*), etc.

On the other hand, we build a compatibility matrix whose lines correspond to criteria extracted from the user profile components (cognitive styles and interaction styles) and whose rows are the possible combinations of modalities.

For each combination and each criteria (e.g. capacity to manage of multimodality, respect of preferred modality, field-dependency…) a compatibility factor is calculated using an arithmetic formula that combines the user's profile and the characteristics of the combination. The combination of modalities that results in the biggest sum is considered as the most compatible one.

Indeed, An ASP program on the server side builds an enriched XML document that contains the whole page to be presented. Each part, which is presented as a tag, has an attribute called *etat* (*state*). This attribute may hold the values 1 or 2, where 1 corresponds to the reduced form of the output modality and 2 is the full form. Thanks to the user profile and the items priority (i.e. the important items which have to be shown), the ASP program include the state values into each (figure 3).

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```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XML Spy v4.3 (http://www.xmlspy.com) by ICTT -->
<!DOCTYPE document_memory SYSTEM "memory.dtd">
<?xml-stylesheet type="text/xsl" href="Memory.xsl"?>
<document_Memory>
&profil;
 <texte priority ="2">        etat equals 2,  full text is displayed
   <titre>Memory</titre>
   <contenu etat="2"> Memory is the most present and most widely used function in the majority of our acts : to remember a telephone
number
- to remember the name of people you know
- to tell your friends what you did last week-end (with all the details)
- to quote a date in history and you have to search in your memory to remember your weekly schedule as well as find thirty years-old
memories. Thus, thanks to received information, your memory enables you to constitute a stock : of cultural references shared by a
social group (1776, the US declaration of independence), of personal memories,
of motor procedures (such as how to use a tool in a preferment way). These pieces of information are afterwards called upon whenever
wanted, in a direct way (which word did you learn), with the help of a hint (the word to find is the name of a flower), or by picking them
among others ( tulip, petunia or peony ?). Variants are great among individuals according to their age, sex or education level... Whether
you are an adult or a teenager, at every moment of the day, at work, or at home,
you use a wide range of faculties named cognitive functions.
   </contenu etat="2">          etat equals 0,  reduced text is displayed
   <contenu>
Memory is the most present and most widely used function in the majority of our acts:
to remember a telephone number- to remember the name of people you know,
to tell your friends what you did last week-end (with all the details)- to quote a date in history
   </contenu>
 </texte>
 <graphique priority ="1">
   <titre>Image</titre>
   <image etat="2">brain_labeled.jpeg</image>
   <image etat="1"> little_brain.jpeg</image>
 </graphique>
 <sound priority ="1">
   <icone etat= "1"> ico.jpg</icone>
   <son etat= "2"> son.wav</son>
 </sound>
</document_Memory>
```

Figure 3: XML document for the document Memory

In Figure 3, we present the XML document of the sub-item DEFINITION. According to the user profile, the XML document is first modified in such a way that the relevant tags are attributed with the corresponding states values. The stylesheet is then applied to this document by formatting the relevant tags of the document(figure 4).

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:fo="http://www.w3.org/1999/XSL/Format">
<xsl:template match="/">
    <html>
        <body bgcolor="#0000FF" text="#FFFFFF">
            <xsl:apply-templates select="document_Memory"/>
        </body>
    </html>
</xsl:template>
<xsl:template match="document_Memory"><b><div align="center"><font face="Verdana, Arial, Helvetica, sans-serif" size="6"><xsl:value-
of select="texte/titre"/></font> </div></b>
<table align="center" width="75%" border="0" cellpadding="0">
  <tr> <td><xsl:apply-templates select="texte"/></td> </tr>
</table>
<table align="center" width="75%" border="0" cellpadding="0">
 <tr><td><xsl:apply-templates select="graphique"/></td> </tr></table>
 </xsl:template>
<xsl:template match="texte">
<xsl:choose>
<table>
<xsl:apply-templates select="node()[@etat='2']"/>
</table>
<table>
<xsl:apply-templates select="node()[@etat='1']"/>
</table>
...
```

Figure 4: XSL document for formatting the document "Memory".

The corresponding tags are selected and formatted as described above. Hereafter, we show an example of the output documents. In the first image (figure 5), the two modalities *TR* and *IC* are chosen while *TC* and *IR* modalities are adopted in the second image (figure 6).

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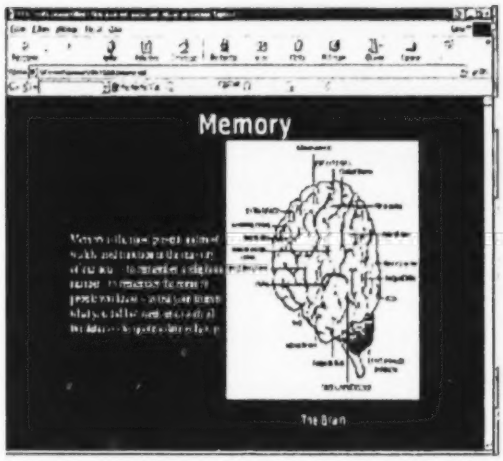

Figure 5: Output document with modalities TR and IC

Figure 6: Output document with modalities TC and IR

CONCLUSION

In this paper, we have described how to generate and then incorporate the cognitive profile into adaptive multimodal interfaces. The first step consists in building the user cognitive model through a set of interactive exercises. Based on demographic data, this model combines 2 different types of information: cognitive indicators and style indicators. This profile is the input of the last step of the adaptation process, where the couples (indicators, multimodal combinations) are evaluated with weighting factors. These factors enable to select the most compatible output documents.

As we know that it can be very dangerous to completely rely on our adaptation process, the most compatible items are presented and the less compatible ones can be shown as catchwords using auditory and iconic information. The user can have more information by clicking on these elements. Indeed, additionally situations where spoken and written text deliver non-redundant information could be of interest [Elting, 2002]. An extension of our work will be to learn of these kinds of behaviours, which can induce that our profile has to be corrected.

The first working track has been defined, experimentation and validation work are currently in progress especially to determine the compatibility factors. However, we are leading experimentation upon a population of 50 users to validate the cognitive profile generation process. The aim is to construct a reliable user profile in order to exploit it not only in our site but other coming applications. To evaluate the adaptation process, we are going to compare the amount of learned information between several populations confronted to different presentations of our course. This experimentation, planed in 2002 summer, will be done on HAPPYneuron's users grouped according to their profile. Adapted presentations and non adapted presentations will be proposed and results will be compared. Results will be presented to the conference.

According to theories guide-lines and to our preliminary work we can say that this research field will be promising and fertile with new developments. All this work has been possible by adopting multidisciplinary approach i.e. computer science, cognitive psychology and neuro-psychology.

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